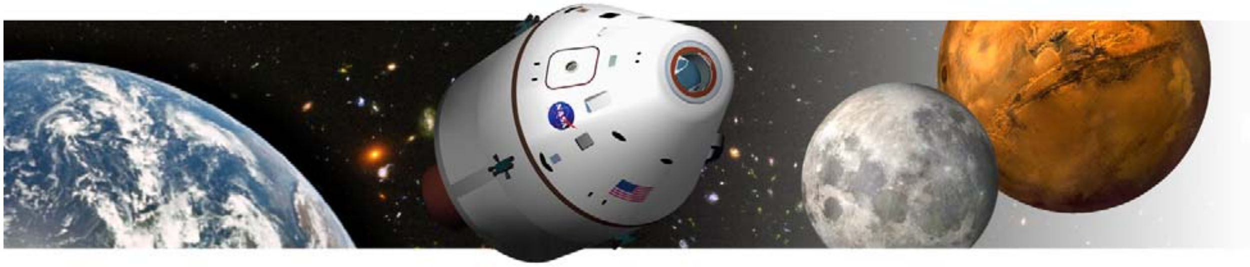
National Aeronautics and Space Administration



Neutral Buoyancy: Astronaut Training is not Always "Sink or Swim."

9-12 National Science Standards:

Physical Science: Structure and Properties of Matter, Motion and Forces.

Summary:

Do you ever get that "sinking" feeling that your students don't understand the concept of buoyancy? Use this short video and accompanying notes about astronaut training to help your students rise to the top.

Featured Imagery Component:

NASA 60 second Brain Bite video, "Why Do Astronauts Practice Underwater?" To view this clip, please visit: http://brainbites.nasa.gov/underwater/

Post-Video Discussion:

1. What is density?
2. What determines whether or not an object will float in water?
3. What is Archimedes' Principle?
4. What is NASA's Neutral Buoyancy Laboratory (NBL)?
5. What is the advantage of working in a neutrally buoyant environment?
6. How does training in the NBL prepare astronauts for working in space?
7. Does the NBL duplicate the working environment of space?

1. Density is the ratio of an object's mass compared to its volume.

2. An object will float in water if its average density is less than that of the water (1.0 g/mL).

3. Archimedes' Principle states that any object that floats displaces an amount of liquid equal to its own weight and is pushed up by a force equal to the weight of the liquid displaced.

4. Astronauts are lowered into a 12-meter (40-foot) deep pool called the Neutral Buoyancy Laboratory (NBL). Astronauts and objects in the NBL are not weightless. They attain neutral buoyancy. That condition exists when objects have an equal tendency to float or sink. Instead, they seem to hover. Since people in swimming pools tend to float to the surface, astronauts (and other objects) are weighted so they neither float nor sink. That's neutral buoyancy. Scuba divers also weight themselves to become neutrally buoyant. The pool needs to be 40 feet deep in order to fit mockups of the International Space Station (ISS) and the space shuttle payload bay, with enough room on all surfaces of the mockups to conduct practice sessions. Astronauts could actually become neutrally buoyant in any water that is as deep as their body.

Try this activity: Teachers might wish to take their students to a local swimming pool and without touching the bottom of the pool have them try holding differently weighted objects until their bodies neither rise to the surface nor sink. Once they have met this challenge, they have successfully simulated the experience of a neutrally buoyant astronaut. You might go one step further and give your students tasks to do in the water while neutrally buoyant, such as fitting together pieces of PVC pipe according to your pre-determined configuration, in order to give your students a simulated astronaut training session.

5. When neutrally buoyant, heavy objects move more easily and a person may feel light and tend to drift and hover. This is similar to how it feels to be in the microgravity of space. (The exception would be objects that have a large surface area tend to produce a lot of drag that inhibits movement in water.) Extra-Vehicular Activities (EVAs), also called space walks, are practiced underwater. Many tasks to be done in space are rehearsed several times in the NBL.

6. Full-scale working models of the Space Shuttle and ISS robotic arms fit inside the NBL. This allows astronauts to practice EVA maneuvers before they head into orbit. All of the US International Space Station (ISS) elements fit into the NBL with the exception of the deployed solar arrays and radiators. They are not in the proper geometry due to the size constraints of the facility. The truss is laid out in a U shape rather than in a line.

7. Working in the NBL is similar to working in space, but there are two significant differences. The suited astronaut in the NBL isn't in a microgravity environment. Even though neutrally buoyant, the astronaut feels his/her weight. Secondly, the drag of water acts to hinder motion. The effects of mass are present in microgravity. Objects still have inertia and crewmembers have to be careful when transporting large masses. In some ways that effect is less in the water because the drag of the water works against inertia and helps to slow down objects with large mass.

Suggested Activities:

Buoyancy: Archimedes Principle
http://www.grc.nasa.gov/WWW/K-12/WindTunnel/Activities/buoy_Archimedes.html

Overview: aerostatic machines, such as hot air balloons and lighter than air-type craft, rely on the differences in air density for lift. This lesson is concerned with aerostatic machines that are dependent on buoyancy.

Neutral Buoyancy and Simulated Weightlessness
http://quest.nasa.gov/neuron/teachers/stellar/Neutral.html

Overview: In this activity, students are introduced to NASA research that uses water immersion experiments to study the effects of weightlessness on the vascular system. The goal of the activity is to build a model of a closed vascular system that has neutral buoyancy. This model consists of a drinking straw filled with air and yellow water, suspended in a tub of clear water. By experimenting with different amounts of water in the straw, students will calculate the ratio of air to fluid needed to attain neutral buoyancy. NASA scientists study giraffes, bats and other animals to learn about how blood circulation in mammals is adapted to gravity. NASA biologists also use water immersion experiments to simulate weightlessness and to investigate ways to counteract the effects of microgravity on the vascular systems of astronauts.

Additional Resources:

Behind the Scenes at NASA: The Sonny Carter Training Facility (NBL)
http://spaceflight.nasa.gov/shuttle/support/training/nbl/